The U.S. Eastern Continental Shelf Carbon Cycling Project: U.S. ECoS

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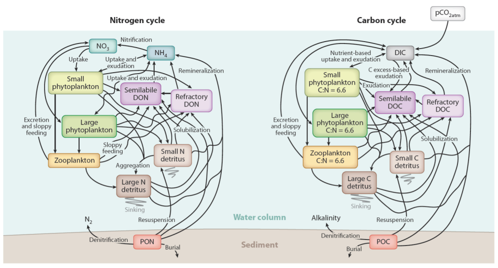
USECoS PROJECT OVERVIEW

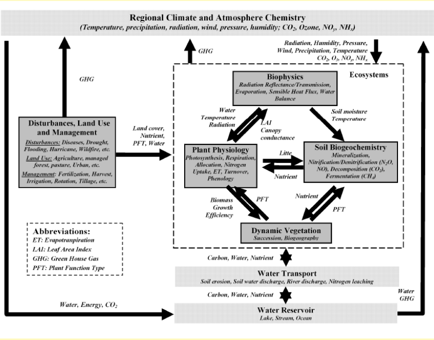
Although the oceans play a major role in the uptake of fossil fuel CO_2 from the atmosphere, there is much debate about the contribution from continental shelves, because many key shelf fluxes are not yet well quantified: the exchange of carbon across the land-ocean and shelf-slope interfaces, air-sea exchange of CO_2, burial, and biological processes including productivity. Because of the undersampling typically associated with most observational studies, model-derived carbon flux estimates are likely to be the only viable approach for defining these fluxes in a consistent manner on annual time scales. The goal of the USECoS (U.S. Eastern Continental Shelf Carbon Cycling) project is (1) to quantify these coastal carbon fluxes in this region using models quantitatively evaluated by comparisons with observations, and (2) to establish a framework for predicting how these fluxes may be modified as a result of climate and land use change.

OCEAN BIOGEOCHEMICAL CIRCULATION MODEL



Schematic of the biogeochemical model that is incorporated into the Regional Ocean Modeling System (ROMS). The model is based on Fennel et al. (2008, GRL) and Druon et al. (2010). As described in Hofmann et al. (2008, 2011) the model has been modified using field studies, historical data, measurements from satellites, and one-dimensional data assimilative modeling. For more information on the 1-D and data assimilative modeling, please see Poster 22 by T. Tian and Poster 294 by Y. Xiao).

DYNAMIC LAND ECOSYSTEM MODEL



Conceptual diagram of the Dynamic Land Ecosystem Model (DLEM). The DLEM will be used to generate riverine freshwater and nutrient input which will be used to force the coastal ocean model. For more information on the details of DLEM and preliminary results in the USECoS region, please see Poster 21 by H. Tian.

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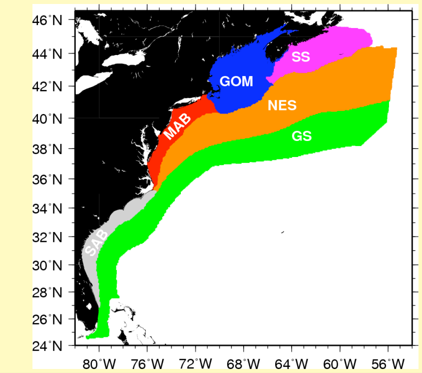
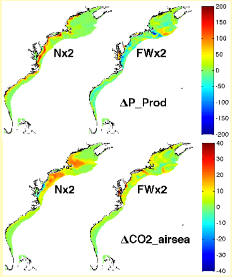


Map of the U.S. East Coast showing the boundaries of the Mid-Atlantic and South Atlantic Bights (MAB & SAB) and the Gulf of Maine (GOM) used in the USECoS analyses.

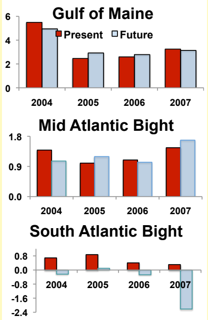
IMPACTS OF CLIMATE AND LAND USE CHANGE



Above: Summer anomalies of primary productivity (PP) and air-sea CO2 flux [units of gC/m2/y] generated by doubling nutrients (Nx2) and freshwater (FWx2) .

The sensitivity of biogeochemical cycling to changes in river discharge is examined through simulations that double and halve freshwater and nutrients individually and simultaneously. Results indicate that doubling river input increases air-sea CO_2 flux more than productivity (PP). Whereas increases in nutrient discharge increase both air-sea CO_2 flux and PP, increases in freshwater input enhances stratification which causes increases in air-sea CO_2 flux, but decreases in PP. (See Poster 20 by J. Xue.)

To investigate how shelf carbon cycling will be altered by variability in atmospheric forcing, simulations were performed using atmospheric anomalies derived from two 10-year simulations of the regional climate model RegCM3 representing present and end of century conditions. Results indicate that variability in atmospheric forcing can significantly alter regional CO_2 fluxes. The South Atlantic Bight, for example, changes from a sink to a source of atmospheric CO2. (For more details, see Poster 11 by B. Cahill.)



Above: Air-sea CO_2 fluxes (Mt C/yr) for the present (years 2004-2007) and future simulations (end of century).

References:

Druon et al., 2010. Modeling the dynamics and export of dissolved organic matter in the northeastern U.S. continental shelf. Estuarine, Coastal and Shelf Science, 88, 488-507.

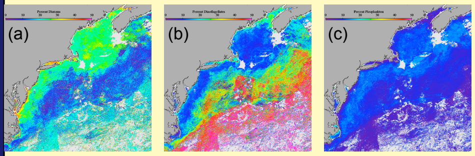
Fennel et al., 2008. Denitrification effects on air-sea CO2 flux in the coastal ocean: Simulations for the northwest North Atlantic, GRL, 35, L24608.

Hofmann et al., 2008. Eastern U.S. continental shelf carbon budget: integrating models, data assimilation, and analysis. Oceanog., 21(1), 86-104.

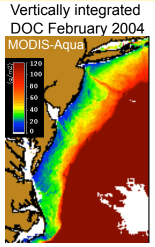
Hofmann et al., 2011. Modeling the dynamics of continental shelf carbon. Annual Review of Marine Science, 3, 93-122.

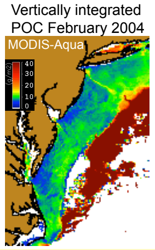
Pan et al., 2011. Remote sensing of phytoplankton community composition along the northeast coast of the United States. Remote Sensing of Environment, in press.

SATELLITE DATA ANALYSES

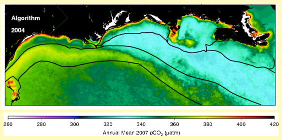


Above: Preliminary results for percent of total chlorophyll made up by (a) diatoms, (b) dinoflagellates and (c) picoplankton, as determined from regional species-specific algorithm (Pan et al., 2011).


Vertically integrated DOC February 2004


Vertically integrated POC February 2004

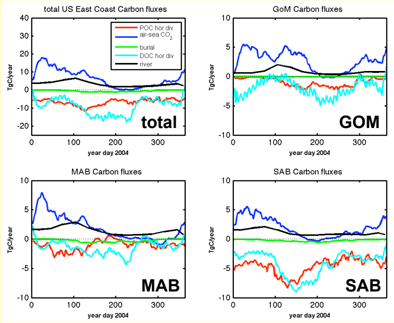
Our ocean biogeochemical circulation model is being evaluated with multiple remote-sensing products. In addition to standard products such as SST, chl and PP, we have also developed regional algorithms for species specific chlorophyll (see Poster 216 by K. Hyde), DOC and POC (see Poster 105 by A. Mannino) and pCO_2 (see Poster 83 by S. Signorini).



Above: Annual mean surface pCO2 (uatm) for the USECoS region of study, as determined by a regional algorithm based on SST, chl and the in situ Takahashi database.

Left: Vertically integrated dissolved organic carbon (DOC) and particulate organic carbon (POC) as determined by regional algorithms developed from in situ data collected along the U.S. eastern continental shelf.

SIMULATED CARBON FLUXES



Above: Annual time-series of the rates of carbon input to the GOM, the MAB, the SAB and total (GOM+MAB+SAB; note different scale in this case) via river discharge (black), burial (green), air-sea CO_2 flux (blue), and the horizontal divergence fluxes of POC (red) and DOC (cyan).

The coupled ocean biogeochemical circulation model is now being used to compute carbon fluxes along the U.S. eastern continental shelf. Initial results indicate that presently this region acts as a sink of atmospheric CO_2 of roughly 6.5 TgC/year (see Table below). Offshore transport of POC and DOC are each roughly 10 times greater than burial on the shelf.

Region	River	Air-sea CO_2 flux	Burial	Horiz Div POC	Horiz Div DOC
Total	3.4 ± 0.3	6.5 ± 0.9	-0.5 ± 0.1	-6.7 ± 0.3	-8.9 ± 0.8
GOM	0.8 ± 0.1	2.6 ± 0.3	0.0 ± 0.0	-1.0 ± 0.1	-1.9 ± 0.3
MAB	1.4 ± 0.1	1.9 ± 0.4	-0.3 ± 0.04	-1.1 ± 0.2	-1.4 ± 0.2
SAB	1.1 ± 0.1	1.9 ± 0.3	-0.2 ± 0.03	-4.6 ± 0.3	-4.2 ± 0.4